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MECHELECIV

THE STUDENT-RUN MAGAZINE OF THE SCHOOL OF ENGINEERING AND APPLIED SCIENCE AT THE GWU

PUBLISHED IN COOPERATION WITH THE ENGINEER ALUMNI ASSOCIATION

the Engineers' Council at the gwu

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A Polaris missile emerges from the sea in the first underwater launch of a missile from a submarine. See the "Alumni Achievements" section for the story (page 8).

-Legal Notes-

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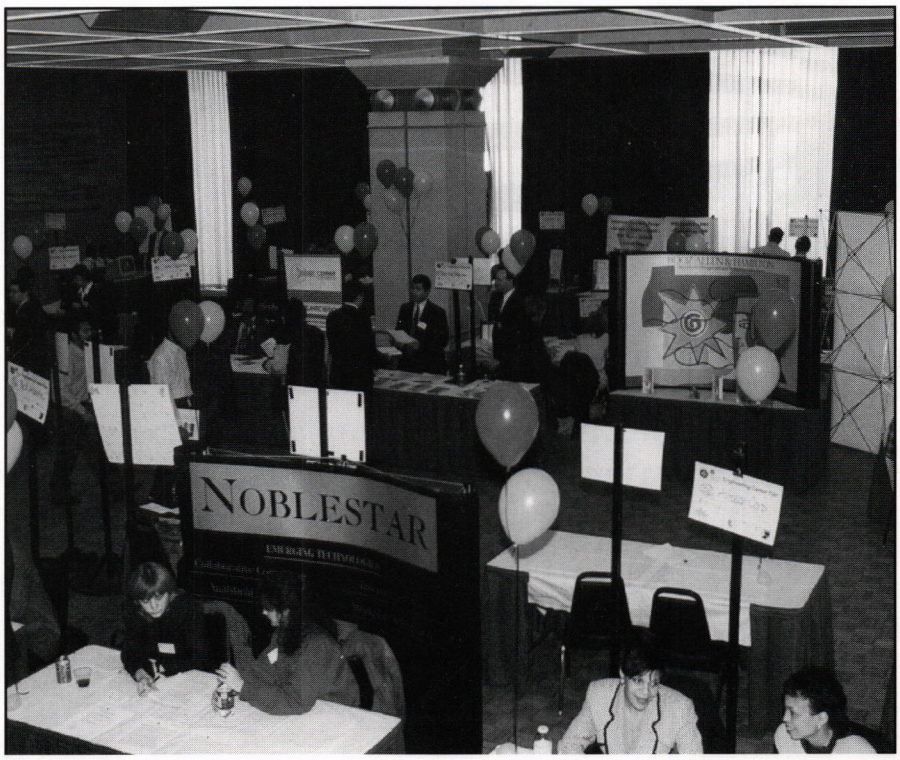
Career Fair Benefits Students

Finding the road to success in the Information Age may be more time consuming than you think.

People are inundated with pages upon pages of information.

A nationwide job-search conducted over the world wide web has made possible the retrieval of hundreds of possible listings with an effort of only a few mouse clicks.



SEAS Students and employers make connections at the first Engineering Career Fair

However, these alphabetically arranged job listings provide virtually no corporate information.

What time is gained by utilizing an on-line search is lost in sifting through countless other on-line documents to thoroughly research possible employment opportunities.

The interaction between employer and job-seeker is lost behind the lines of text sent via wire from one mainframe to another.

With this in mind, the most important step in the search process is the development of contacts with prospective employers.

Career fairs are an ideal medium for marketplace assessment, whereby job-seekers may focus on the companies, fields, and opportunities which best suit their individual career endeavors.

While the annual Career Fair hosted by The George Washington University's Career Center does include a number of technology-oriented companies, it does not cater specifically to engineering companies.

Last semester, the Engineers' Council took the initiative to design a career fair which catered to the needs of engineering students.

With assistance from the members of the Career Center staff, Bill McCarthy, Anne Scammon, and Karen Mitch, Julia Sugg and Sergio Yanes attracted over 30 local and national companies to The George Washington University's first annual Engineering Career Fair (ECF).

The roster included such names as IBM, the Central Intelligence Agency, and Bell Atlantic. All engineering disciplines were represented at the ECF.

Over 300 individuals attended the inaugural ECF.

Students scoped out potential employment interests all under one roof.

Along with full-time recruitment, co-op and internship opportunities were also available through several of the companies at the Fair.

With the exceptional success of the first Engineering Career Fair to model from, Sugg will be organizing ECF '98, along with new co-chair Grant Guthrie.

ECF '98 hopes to expand on the success of Spring '97's ECF. Guthrie hopes to double the number of firms attending ECF '98.

He plans to achieve this goal

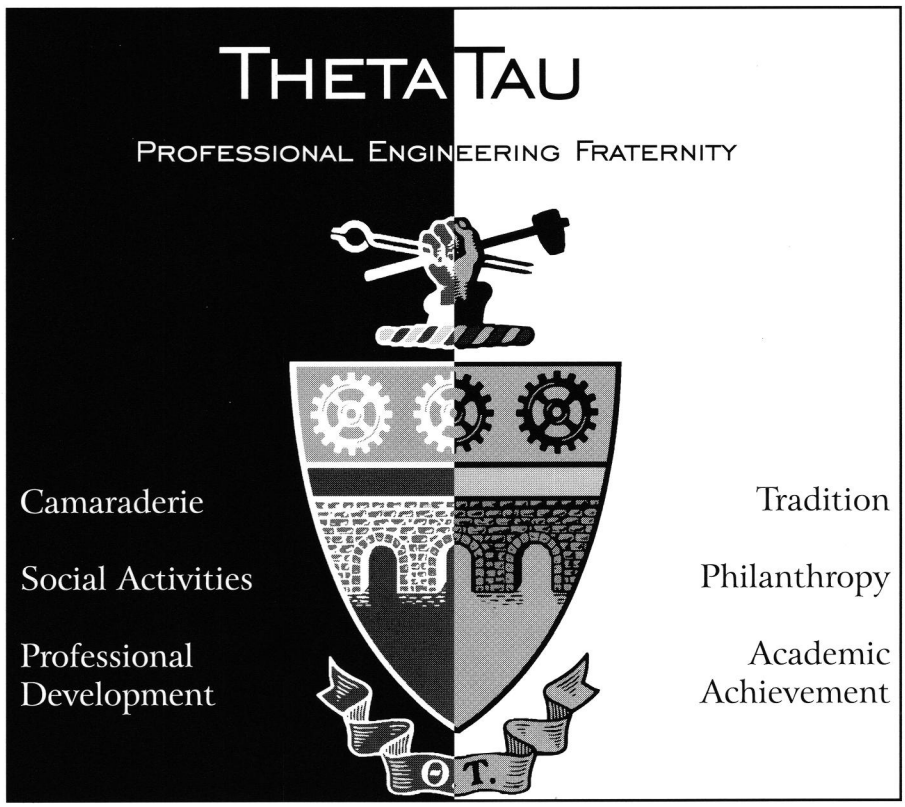
with a more directed search of companies in the engineering field.

Sugg is looking forward to inviting a number of companies with which she has developed contacts since this year's event.

A greater diversification of civil and mechanical engineering companies is sought in addition to the prominent electrical engineering and computer science related companies which attended the career fair this year.

The ECF has proved to be a valuable asset to the School of Engineering and Applied Science. Guthrie recommends that rising underclassmen and graduate students alike should not pass up the valuable opportunity to visit the Engineering Career Fair next year.

~Jon Roepke



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IT'S CHANGED!
THERE ARE A FEW SPECIAL THINGS THAT WE CAN REALLY COUNT ON TO HELP US ACCOMPLISH ALL THAT WE NEED TO DO. RELIABLE, DEPENDABLE THINGS LIKE THE TOYOTA COROLLA. OVER THE PAST 30 YEARS, COROLLA HAS BECOME ONE OF THE MOST TRUSTED CARS IN THE WORLD. AND NOW IT'S ALL-NEW...WITH MORE PASSENGER AND TRUNK ROOM, AN ALL-NEW ALUMINUM ENGINE THAT'S ONLY MORE POWERFUL, IT'S MORE ECONOMICAL...UP TO 38 MILES PER GALLON HIGHWAY. COROLLA IS SAFER AND QUIETER, AND BEST OF ALL, IT STARTS AT A PRICE LOWER THAN LAST YEAR. MORE CAR...LESS MONEY. WHAT A REFRESHING CHANGE!
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Trials and Tribulations of the First Polaris Missile Launch

The successful firing of two Polaris missiles on July 20, 1960 marked one of the most significant milestones in U.S. Naval history. The Polaris Missile System greatly enhanced the U.S. Navy's capabilities and marked the dawn of a new era in strategic warfare. However, the successful launchings included a series of experiences which were not recorded or documented.

The actual launching of the missiles was uneventful compared to the excitement which occurred on July 18, 1960; two days before the historical launchings.

On that Monday, which was the scheduled day for the first launching, we went to sea at 0500 in order to meet first launch time at 0900. We left Cape Canaveral with 122 people aboard the George Washington submarine. This included not only the crew, but many notables including Dr. Draper of MIT, Dr. Kistakowski representing President Eisenhower, and various executives in the Navy Department, including CNO Adm. Arleigh Burke and Adms. Rayborn and Levering-Smith who led the Special Projects Office in the creation of the Polaris Missile System. There were also technicians and engineers of the major contractors involved in the effort, including a seven-man team from the Johns Hopkins Applied Physics Laboratory, people from the Electric Boat Company, Westinghouse, Interstate Electronics Corporation, Massachusetts Institute of Technology, plus several others.

That Monday was a day of intense, unforgettable drama. This first aborted attempt identified the unforeseen dangers involved in launching a live missile from underwater. We were apprehensive because this had never been done before and the possibility of an in-tube explosion during the launch phase of a live missile was always with us. We made plans and rehearsed emergency actions in case of possible malfunction readouts on the launcher panel; due to what happened on that first launch attempt, we were lucky to have done our homework.

For many months we had practiced launching with sabots. Sabots are underwater pistons and we had launched those in order to determine the characteristics of the launch system. However, these have no live missile motors involved, and the danger of an in-tube detonation was not present during those test runs.

The countdown on missile number one proceeded normally up through and including T minus two minutes during which other critical ship functions such as hatch openings, arming of firing circuits, etc. were implemented. There were several indicators on the preparation panel consisting of switches, fuses, relays, transformers and meters in large metal cabinets known as the "launch panel" manned by the ship's blue crew under the control of the launch officer, Lt. Don Johnson. I acted as the APL/JHU technical adviser to the launch officer. The indicator lights were very important, especially late in the count. At approximately T minus two minutes, the retract mechanism for the non-tactical test and evaluation (T&E) package in the missile's reentry body was withdrawn. The main tactical missile umbilical was also withdrawn. Although the T&E retract mechanism was not tactical, it played an important part in the subsequent events. If this retract mechanism did not function properly, the very large electrical receptacle, which had about 40 pins, would be lodged in the tube. If the missile was then launched, the T&E connector hanging in the tube would have probably ripped out the side of the propellant loaded missile case. This could have resulted in a detonation in the tube and, since we were underwater, this would not have been a very joyful experience.

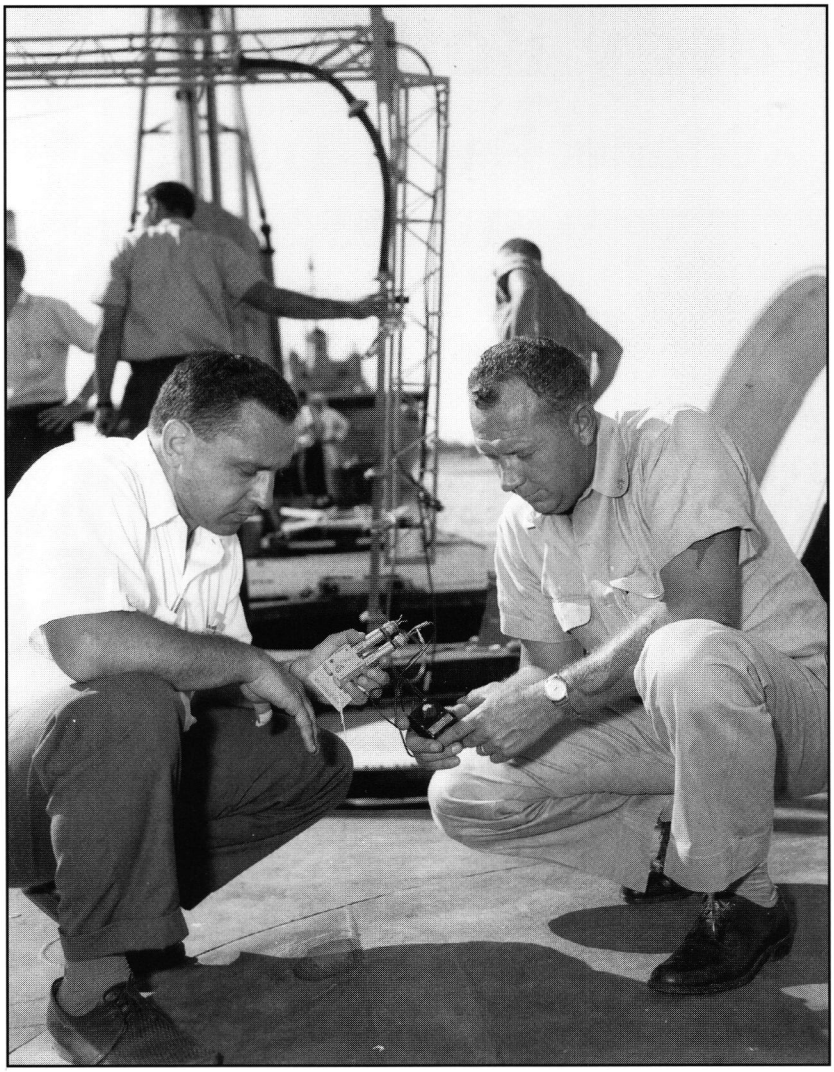
At T minus ten seconds the first attempt to retract the T&E mechanism was initiated which caused the indicator lights on the panel for that particular function to go from red to green and then out completely.

With only seven seconds left in the count I instructed Lt. Johnson to kill the count, and he in turn hit the "panic button". The reason for this very late time in the countdown to retract is that there is a battery in the T&E package which was activated as late as possible in order to get the

most flight data.

This abort resulted in Commanding Officer Osborn and Adm. Rayborn, who were in Control at the time, promptly charging down one deck to the launch area to investigate why we killed the countdown at that critical point. Explaining the light anomalies was painful because it was felt by some that this was just a "light bulb" failure, which had happened frequently. We explained to the group which now also included Drs. Draper and Kistakowski and SPL's Morton, now assembled in the launch panel area, that this was a high risk situation because of the possibility that the T&E connector would be hanging in the tube and could rip open the motor case at launch.

At this point, the Lockheed people reminded us that the main missile battery was now on internal power and that if the battery was not used for the functions of flying the missile, it would build up toxic gases and acidic fluids and would explode in approximately 20 minutes. This led to a fevered activity to get into the launch tube and remove the battery from the missile reentry body. If we did not, we would have a battery explosion in the tube. This would not have been good because the gases would give off toxic fumes and could well affect everybody on the boat. Capt. Osborn then surfaced the submarine and we proceeded to try to get the battery out of the reentry body. At the same time we checked to see where the T&E umbilical rested, and sure enough, it verified our worst fears. The umbilical was still partially attached to the missile and would have remained in the tube if we had tried to launch.



Inventor of the hazardous circuit tester Robert E. Kemelhor, left, and W.R. Draper of the USS GEORGE WASHINGTON test electrical continuity of Polaris launch tube

At this point a feverish activity was underway to get that battery from the missile's reentry body. The battery was held onto the guidance system by 50 screws which had to be manually torqued. Two crewmen went into the tube with screwdrivers to get the reentry body out. The submarine was on the surface by this time, however there was water washing across the deck as the sea state was about two or three. Although the men did have their safety belts attached to the safety tracks that ran along the top of the submarine, it was very dangerous to be topside. The removal of the screws was a long, drawn out affair and about 22 minutes into the operation, the head was finally pulled out and access to the battery was attained. Sure enough, the battery was already billowing. The case was ready to burst. The crewmen in the tube grabbed the battery and handed it up to the people on the deck. Lt.

Continued on page 12

Foggy Bottom Transit Authority:

a Model Rapid Transportation System with Ada 95 Software Control

Foggy Bottom Transit Authority (FoBTA) is a computer-controlled HO-scale model of an urban rapid transportation system based loosely on Metrorail, the rapid rail network of Washington, D.C. and its suburbs in Maryland and Virginia. The name Foggy Bottom refers to the neighborhood in which The George Washington University is located, near the Potomac River and midway between the White House and Watergate. The area is low-lying and was originally swampy, hence the name Foggy Bottom.

FoBTA models a part of the Metrorail system using off-the-shelf HO model railroad equipment and some additional electronic parts, along with a computer running the GNU Ada 95 compiler (GNAT) under the Linux operating system. This project was inspired by the successful work of John McCormick and his students [McCormick 92]. Our work differs mainly in that we are modeling a rapid transit system instead of a conventional freight railroad.

Associated with the Metrorail model is a new upper-level real-time systems course.

WHY METRORAIL?

Metrorail was conceived in the 1960s and designed as a 100-route-mile, state-of-the-art urban rail system. Its first 4-mile segment opened twenty years ago and its final segments are scheduled for opening in the next five years or so. Currently, roughly 80 miles—divided between tunnel segments in the central city and open-air lines in the outlying areas—and 70 stations are in service. Figure 1 shows the Metrorail route map.

Metrorail carries some 500,000 passengers per day, which makes it the second-busiest urban rail system in the U.S., after New York. Passengers are carried in several hundred cars, running at up to 65 mph in trains of up to eight cars. There are no locomotives; all cars are powered by 600 volt DC current, drawn from a third rail mounted alongside the running rails.

Metrorail is an interesting system for us to model because:

*A rapid transit system is operationally very different from a conventional railroad. Station stops are quite frequent, and a number of trains can be running on the same line simultaneously with only minimal spacing between trains. This density of operations results in interesting train-control problems to avoid rear-end collisions.

*Students are quite familiar with Metrorail and often ride it; the Foggy Bottom-GWU station lies directly under our campus.

* Metrorail is, in fact, a computer-controlled system. The human "operator" in the front cab is, under normal operating conditions, responsible for pressing a button to close the doors and give the start signal; the train is "driven" to its next station automatically, dispatched by a central control system at headquarters. Various levels of manual override are available in unusual circumstances; the operator is in constant radio contact

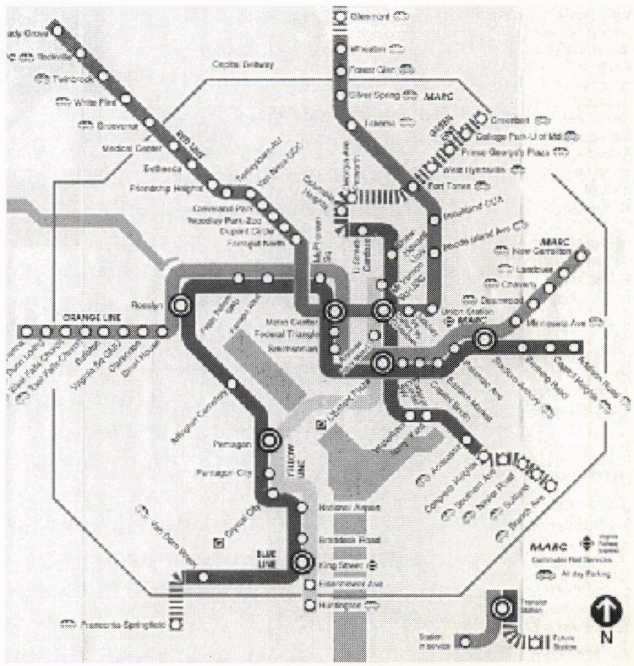


Figure 1. Metrorail Route Map

with the dispatchers at headquarters. This connection to the "real" rail system means that the students are able to view the model system as an engineering project and not just a toy train.

*The real Metrorail software was developed in the 1970s, prior to the Ada era. However, the basic design is reasonably typical of more recent automated urban rail lines in Paris, London, Caracas, Hong Kong, Cairo, Calcutta, and elsewhere, in which much of the software is written in Ada. The "Ada connection" with real transit systems has fostered considerable enthusiasm among the students.

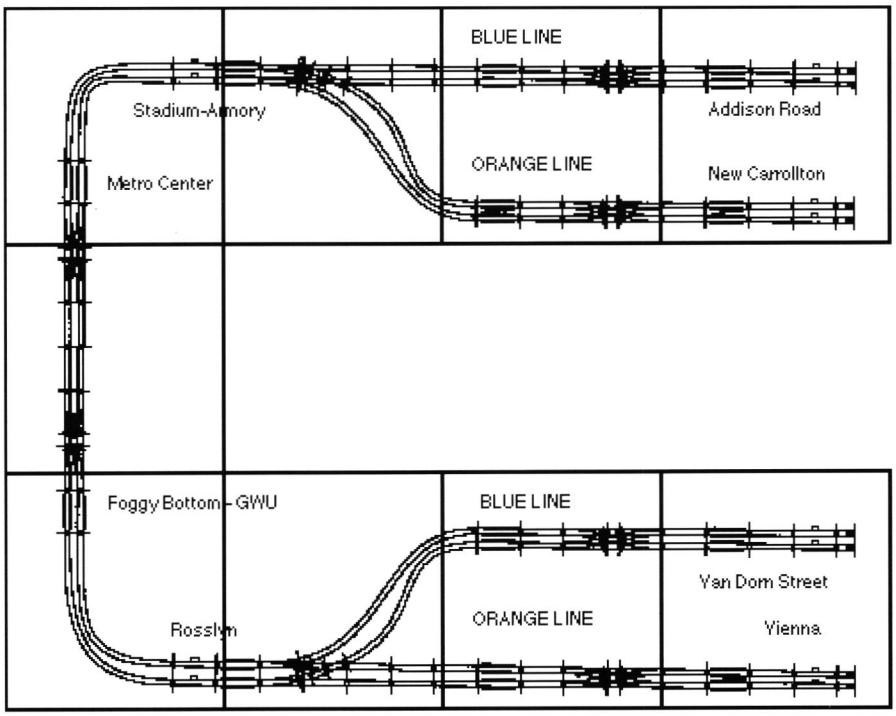


Figure 2. Foggy Bottom Transit Authority Model

The FoBTA Model

The FoBTA model is an HO-scale model of a part of the Metrorail system. HO is probably the most popular standard scale used in railroad modeling. Track, trains, power supplies, and so forth are readily available off the shelf; equipment from different manufacturers is generally interoperable. HO is 1/87 scale: One foot in the model represents 87 feet in real life. The distance between the track rails—56.5" in real life—is about 5/8" in the model; a model of an 85-foot passenger car is just under a foot long. We were pleased to discover that one of the major manufacturers, Walthers, makes a faithful HO-scale model of the Metrorail passenger cars. These plastic cars come in kit form, so each one must be assembled with simple tools and model cement.

HO-scale equipment is solid and of manageable size; on the other hand, a true scale model of a 20-mile Metrorail line would require nearly 1/4 mile of model track. This would require laboratory space well beyond reasonable expectation in an urban university! We have therefore decided to construct a model loosely based on the topology of a section of Metrorail, namely, the Blue Line/Orange Line pair. As can be seen in the route map of Figure 1, Blue and Orange share common trackage in the central area, and each line follows its own eastern and western branches out to their respective endpoints.

A scale drawing of our model is shown in Figure 2. As can be seen in the figure, the critical points in the model—stations, junctions, and crossovers—are reasonably faithful to those in the actual system.

The model is a shortened version of the real Blue/Orange pair, bent into a U shape to fit into the available laboratory space. Each ruled square on the figure represents a 4-foot by 4-foot plywood table; the tables are bolted together to make a stable layout. Each line is roughly 36 feet from end to end. The layout was designed using a model railroad CAD package for Windows called Right Track Software.

Phased Implementation

We are constructing this model in three phases.

Phase 0: *Manual Hardware, Software Simulations*

In this phase, the rail system model is not connected to the computer, but rather operated manually with standard HO controllers. The purpose of this phase is to familiarize us all with the performance of the trains themselves, while we experiment with Ada 95 software simulations of rail transit systems.

As part of this early prototyping, we discovered that the model Metrorail cars were not powerful enough to climb the abnormally steep grades in our

first design. These grades were needed to allow a "fork" (where two lines split from the central trunk) to be implemented with bridges—as the real Metrorail is—to avoid having one track physically intersect another. The grades were very steep because of our short distances between stations. The situation caused a redesign to eliminate the grades altogether. The resulting intersections are less realistic, but actually make the system more interesting because they provide additional critical points requiring physical mutual exclusion.

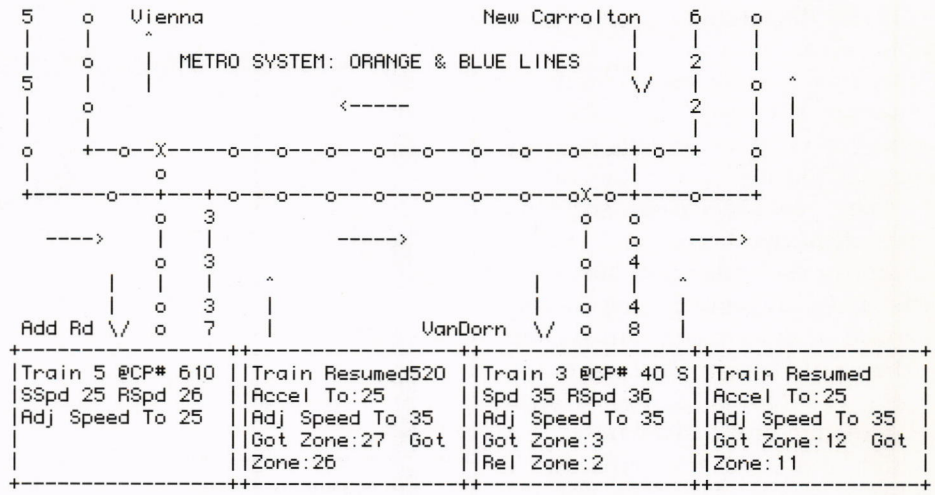


Figure 3. Typical Student Project Display

PHASE 1: *Smart Tracks, Dumb Trains*

Our next phase, which we are constructing at this writing, connects the train layout to the computer via sensors between the rails at critical points. A train passing over a sensor sends an interrupt to the computer. We call this the "smart tracks, dumb trains" model because trains are allowed in, or barred from, track segments simply by turning power to that segment on or off. This is a relatively simple model, requiring no special hardware on the trains beyond a simple device to trigger the sensors.

PHASE 2: *Smart Trains, Dumb Tracks*

In a real rapid transit system, the power rail ("third rail") is continuously energized; it is simply not feasible to switch 600 volt DC current on and off from one track segment to another. Our Phase 1 design is therefore not very realistic, and our long range plan is to build a "smart trains, dumb tracks" model. In this model, each train will carry on-board digital hardware capable of sending and receiving a simple set of signals and controlling the power drawn from the tracks. HO-scale digital control is an emerging technology. Possibly we will be able to buy the on-board hardware ready-made; another approach is to task our computer engineering students with designing and building the hardware.

THE REAL-TIME SYSTEMS COURSE

Computer Science 190, Real-Time Computer Systems, was offered for the first time during the Spring 1996 semester. This course is intended for seniors and can also be taken for graduate credit. The students are assumed to know sequential Ada, which is taught in introductory courses. In the Spring 1996 class, the students—half undergraduates, half grad students—knew very little of the Ada 95 extensions, having studied Ada 83 several years ago.

We chose the recent book by Burns and Wellings, Concurrency in Ada [Burns 95], as the main text of the course. This book focuses on Ada 95 concurrency, with some attention in later chapters to the relationship of tasks and protected types to tagged types, and to real-time programming. We supplemented Burns and Wellings with selected preprint chapters from Software Construction and Data Structures with Ada 95 [Feldman 96], which was not yet in print at the time of the course.

Lectures

Because the metro model itself was still under construction, this first run of the course relied entirely on software simulation. Students were given the files from the Feldman book, and a discussion on tasking and protected types based on the completely coded Bank Simulation example in Chapter 15 of that book. That example shows concurrency as a modeling technique, using task objects to simulate animate ones (bank tellers and customers) and protected objects to simulate inanimate ones (bank database). The task and protected object interfaces are exposed in package interfaces, so that the active and pas-

sive objects communicate directly with one another. Students were encouraged to reuse ideas and code from the examples.

Most of the course lectures focused on the Burns/Wellings material, along with special topics such as rate-monotonic scheduling. We also took a "field trip," riding the Metrorail system from Foggy Bottom to Van Dorn Street and back, to observe the operation and the overall track structure. Metrorail management is rather closed to discussion of its control systems with outsiders—especially since a control-related fatal crash in January 1996. We were fortunate, however, in meeting a train operator who was riding home from his work shift and took much time and effort in chatting with us about the control system as he perceived it.

Student Projects

Essentially the only graded work in the course consisted of a project. The only requirement was that the project had to focus on a Metrorail simulation. Students designed their own projects, proposed them publicly in class, and demonstrated them at the end of the semester. Team work was optional; we had two 2-person teams and ten "solo practitioners."

Because this was the first run of the course, we were curious as to what the students would come up with if left on their own as to design methods, documentation, and so on, and therefore we did not specify any of this. Some students were also taking the software engineering course, or had workplace experience, and used reasonably formal OOD methods; others invented their own diagrams and other designs. It was very interesting to observe the different styles and approaches.

All projects were implemented using GNAT; most students used the Solaris version on the engineering school server; a few chose to use their home PCs running Linux. We suggested to the students that they try to find simple ways of displaying the state of the simulation. We advised them that trying to use graphics packages to produce elaborate high-resolution displays would probably distract them from the important part of the work, namely, developing a clear model of the system and getting it to run correctly. Most of the students opted to use the simple 24 x 80 ANSI-terminal window manager presented in the Feldman book. That window manager is not concurrency-safe, though, as some discovered when they tried to use it verbatim and produced screens filled with random characters. Naturally they added the necessary mutual exclusion to solve their problem.

One team's window-manager-based display is shown in Figure 3. The upper window gives a simplified Blue/Orange map, indicating individual trains by their 1-digit identifying codes. A dynamic trace of the progress of four trains is given in the four lower windows. This ANSI-terminal display is obviously rather primitive, but a surprising amount of information can be displayed, and the display has the virtues of simplicity and complete portability.

This team developed their project on the Solaris server; after the code was turned in, we downloaded it to a PC and compiled it with the then-new GNAT 3.04 for DOS, the first GNAT DOS release to support tasking. The program compiled and ran the first time! We have since compiled and run the program without change using GNAT under Mach Ten on a Power Macintosh.

Other Related Student Projects

In addition to the students in the real-time course, two others worked on related projects. One was a graduate student pursuing an independent directed-research project in real-time software; the other a senior in the two-semester senior project course. The latter course is the capstone course in our computer science and computer engineering curricula. Students design their projects—hardware, software, or both—in the fall and implement them in the spring. Most students work in teams, though individual projects are permitted. The course is characterized by the requirement to produce cost analyzes, and—at the usual life-cycle milestones—"industrial-strength" documents and public design reviews.

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Students Re-Establish Group

With several thousand members nationally and offices from New York to Hawaii, the Society of Women Engineers (SWE) is an international engineering organization expanding at an amazing rate.

Recently, SWE re-established a university chapter at the GWU School of Engineering and Applied Science.

The primary aims of the Society of Women Engineers are threefold: to inspire women to achieve full potential in careers as engineers and leaders, to expand the image of the engineering profession as a positive force in improving the quality of life, and to demonstrate the value of diversity.

Third Time's a Charm

Surprisingly, this is not SWE's first arrival to The GWU community. In previous years SWE had been an official SEAS organization, yet in 1988 the campus chapter discontinued its membership. The reason for the halt was difficulty in maintaining the SEAS division's charter.

Professor Rachelle Heller, faculty advisor to GWU's chapter and a SEAS Computer Science professor, firmly believes this has been the best resurrection of SWE she has seen. Of the three that Heller has witnessed and played a central part in, this group has had the "greatest team of officers"; that may certainly be the major reason for SWE to last this time around.

Past Successes, Upcoming Plans

For a group which is still installing itself in the School of Engineering and Applied Science, SWE has already had successful ventures.

At the beginning of the fall 1996, SWE welcomed Peter Baher, a writer for *The Washington Post*, for a professional talk. Baher is a computer science technology and economics journalist for the national newspaper and in his visit to GW he addressed his experiences with the engineering environment in the Washington DC area.

Aside from giving information on where to find the best lists of local engineering firms online, Baher also provided maps to show how nearly all of the business locations form a ring, most in Northern Virginia, that surrounds the metropolitan area.

More recently, SWE joined efforts with GW's Wellness Program in sponsoring an evening dedicated to demonstrating relaxation methods to group members. The well-deserved study break featured stress management techniques and massage therapy; SWE plans to repeat the program sometime again.

According to GW's SWE chapter president Aydin Hasan, a Mechanical Engineering major, one of the more exciting plans included in SWE's 1997 itinerary is to have a professional discussion with a female engineer from the Mobil Oil Company.

Hopefully, the speaker would contribute feedback on her real-life experiences as a woman in the predominantly male field of engineering. The discussion would essentially embody part of the SWE mission and demonstrate to the SEAS community what SWE can offer, as well as grant SEAS engineering students with several external male and female perspectives, for possible later reference. When asked about SWE's part in establishing networks, Heller added that, "there is definitely an 'old-boy' network; now there's an 'old-girl' network too."

The Road Ahead

Any new organization will have initial hurdles to pass and SWE has been no exception. Heller claims the biggest challenge posed as of yet to SWE is to become regarded as an indispensible organization. SWE's most pressing goal at the moment is "to be seen as a place worth frequenting," according to Heller.

One of the organization's many principles is to be "an intellectual and physical space" where young women in engineering may address issues concerning themselves, Heller says. SWE hopes to provide an arena where local issues, such as SEAS departmental classes, and loftier issues, such as challenges met by

Continued on page 11

ASCE Provides Opportunity

The American Society of Civil Engineers (ASCE) student chapter at The George Washington University is in full swing with speakers, field trips, social hours, and community service.

The chapter has been involved in community service within the University and the Metropolitan DC community.

ASCE is supporting the Freshman Mentorship and Acclamation Program with over fifty percent of its members involved.

This program, created by the Engineers' Council, matches upper class students with freshman students with the purpose of reducing the drop out rate and increasing the involvement in school activities.

Additionally, the ASCE National Convention was held in Washington DC in November 1996.

GW students participated in the First National Concrete Frisbee Competition, organized by the convention and held in the GW Quad.

Two members, Daniel Betts and Juan Tenze, won second and third places, respectively.

Once again this year, ASCE is sponsoring an entry into the Steel Bridge Competition.

Graduate student Alex Rosenheim expects a good showing at the competition. "We hope to establish ourselves as *the* team to beat in the Atlantic Region," Rosenheim said.

Five field trips were planned as part of the off-campus activities. In the Spring 1997, ASCE toured the MCI Center, the new Redskins Stadium, and a Metro Tunnel Tour.

ASCE members pose for a picture on a recent tour of the Washington Metro

The ASCE GWU Student Chapter is growing and is more active than ever.

For more information come to the Weekly Social Hour on Tuesdays at 12:30 on the Academic Center 7th Floor Conference Room, or call the ASCE Student Office at (202)994-5968.

~ Erica Carr

SWE finds new life at George Washington University

professional women in the engineering field, may be dealt with.

President Hasan finds that the more pressing challenges ahead are within the GW community itself. She would like to see more involvement from two groups, namely incoming SEAS freshmen and male engineering students. The level of male involvement with the recently established group showed a "truly disappointing" level of male interest in SWE, Hasan asserts.

SWE stresses that the organization is assuredly not exclusive and anyone interested in promoting women in engineering is welcome to join.

If you would like more information regarding SWE, please contact President Aydin Hasan at ahasan@seas.gwu.edu.

~Eloisa Tigre

Drama Surrounds Missle Success

Johnson received it and handed it to the chief, who then proceeded to throw the battery overboard.

At this time, while I was in the missile guidance area at the hatch opening, I heard a frightful scream from topside. I found out the problem in a few minutes, when the doctor on board was seen rushing up the ladder to get topside. He shortly came down supporting the Chief who had thrown the battery overboard and appeared to be injured. In his hurry to throw the ready-to-explode battery overboard he had slipped and fell over the side, dangling by his safety belt which caught him in his groin. He seriously damaged the sensitive area. He was brought down the ladder in a rather bloody state.

This was the drama of the first attempt to launch a missile from the George Washington. By the time this crisis had settled down it was decided to launch the second missile. Once again at T minus two minutes, a malfunction occurred in the guidance area as identified by the MIT monitor, who was in the launch area. It turned out that there had been a disconnect of electrical power going to a monitor that checked the guidance platform performance. This again was a non-tactical failure. However, it stopped the count and disqualified the missile.

At that point it was decided to abandon the operations for that day. There were several destroyers, a cruiser, a submarine tender, and the C2 Observation Island which was our instrumentation ship and also had about 100 reporters and photographers on board. We would return to the Cape and tell the observers that we would shortly continue the operation. They witnessed the submarine surfacing and knew little about the drama that had occurred aboard the George Washington.

When we arrived in port at 1800, those of us involved in the "launcher" dashed over to the Navy's underground land-based launcher system. We immediately proceeded to try to figure out why the T&E umbilical did not retract properly, so that the fix could be incorporated for the next set of operations which would hopefully take place the next day.

We worked all that night and figured out that the problem was in two shear pins, which mounted the receptacle to the missile. The pins didn't shear properly because they were not the specified shear pins. Someone had inadvertently inserted stainless steel pins, which were too tough to shear under the pull forces available. Then we redesigned the collar, eliminating one of the pins because it was redundant, and modified the configuration so that it would be more reliable.

We tested that configuration in port 25 times on Tuesday, July 19th 1960. Because we had to do the modifications to the umbilical area on the submarine on Tuesday, we went out on Wednesday the 20th of July and successfully flew two missiles. Both missiles launched satisfactorily, went down range well and essentially initiated the era of submarine launch ballistic missiles, as we know them today.

~Robert E. Kemelhor

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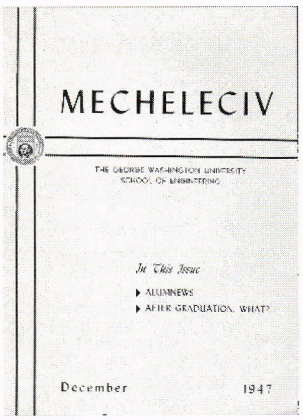

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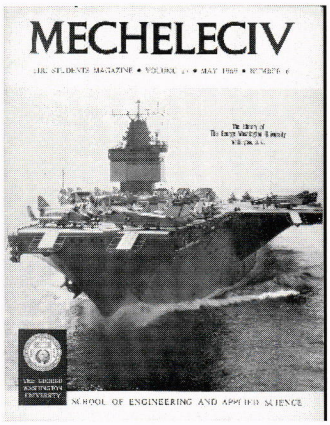

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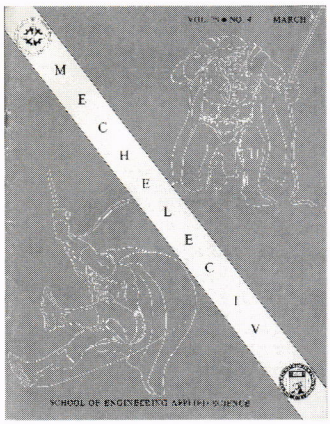

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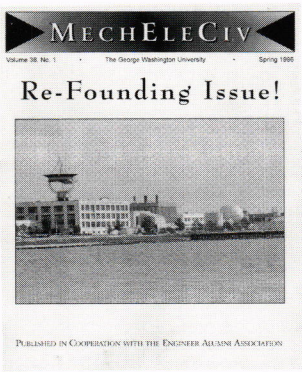

1996

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